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Publication Title:

Externally coating elongate articles with particulate materials

Abstract:

Abstract of GB 1013895

(A) Elongate articles such as pipes and rods are coated by immersion in a bed of dry particulate material which is maintained in a state of aeration between that of a fluidized bed and of a loose settled unaerated bed, the articles being supported and rotated while immersed in the bed, the adhering particles being subsequently converted into a coherent coating layer. The articles are preferably preheated to cause adherence of the particles but in the case of non-thermoplastic materials the articles may first be coated with an adhesive and while still tacky immersed in the bed of particles. Further adhesive material may then be sprayed over this coating layer. As a further alternative electrostatic coating methods may be employed to cause adherence.; Pipes or rods may be rolled through an aerating vessel containing the bed of particles while supported on narrow-edged or toothed rails which minimize the damage to the coating (Figs. 1-3, not shown). Any such damage may be repaired by subsequent heating and compacting operations. Alternatively the ends of the pipes may be supported in and rotated by suitably shaped cup or cone members which may be suspended from overhead rails or supported on lateral supporting rails, Figs. 9-12 (not shown). Immersion in the bed may be achieved by raising the bed or by lowering the articles into the bed and is preferably to a depth of at least two inches but to less than two-thirds of the pipe or rod diameter. The bed of particulate material may be stirred at its base, Figs. 13-15 (not shown), to ensure uniform conditions throughout.; The articles may be heated further after immersion to fuse the coating particles into a coherent layer. In a preferred method the material adhering to the surface of the article is compacted before or during final fusion of the coating by contact with a smooth surface, e.g. that of a presser roller, Figs. 18-21 (not shown), or of a ramp on which the article may roll from the coating vessel, Figs. 1 and 16 (not shown). After fusion of the coating is complete the article is preferably cooled by immersion in water while supported on a resilient material, such as foam rubber, Figs. 1, 15 and 16 (not shown). Air cooling may also be employed.; Coating materials referred to include thermoplastic powders such as polyethylene, polyvinylchloride, chlorinated polyethers, fluorocarbon resins, nylons, heat-curable resin powders such as partly cured epoxy resins, wax powders, and powders of bituminous substances such as coal tar pitch and petroleum bitumen. Unfusible materials such as glass beads, sand, abrasive minerals and the like are referred to. Two aerating vessels may be arranged in succession to produce multi-layer coatings and a bath of primer substance may precede the aerating vessel.

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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Externally Coating Elongate Articles with Particulate Materials.

We, INDEVCO LTD., a Canadian Corporation, of 512 King Street, East Toronto 2, Ontario, Canada, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the external coating of elongate articles by means of a particulate coating material, more particularly the coating of elongate articles having an essentially straight axis of elongation by means of a particulate coating material composed of essentially dry solid particles. The invention relates to a coating process as well as apparatus for carrying out the process.

The process in accordance with the present invention comprises in combination immersing the elongate article in a bed of the said particulate coating material, bringing all parts of the bed in contact with the article into a condition of aeration intermediate between that known as a fluidised bed on the one hand and the condition of the particulate material in its loosest possible self-supporting condition on the other hand; causing particulate material of the bed to adhere to the surface of the article, at least half of the material being caused to adhere while the bed is in the above specified intermediate condition; supporting the article being coated during the entire period of contact with the bed against sinking to the bottom of the bed by means independent of the coating material; maintaining the axis of elongation of the article in an essentially horizontal position during the period in which the coating material is caused to adhere; revolving the article completely around its axis of elongation while in contact with the bed in the specified condition and while the coating material is being caused to adhere; and transforming the coating material adhering to the article into a coherent layer surrounding the article. The said intermediate condition and its use in a coating process is described in great detail in our earlier patent No. 912,464. According to one modification described in the earlier disclosure, the coating material is continuously maintained in the said intermediate condition, the said intermediate condition beng characterised by the feature that the coating material is very free flowing, yet exhibits a slight angle of repose (smaller than that of the unaerated powder), as a rule has a bulk density measurably lower than the bulk density of the unaerated powder in a loosely settled state and in its ideal form exhibits no observable relative movement at all between adjoining particles as long as the bed is not disturbed mechanically, this preferred condition being referred to as a static aerate. The term static aerate is also used for the material itself when in such a condition. In accordance with a further modification the said intermediate condition is a continuously changing condition produced by decreasing the rate of aeration or stopping the aeration of a fluidised bed, thereby causing the bed to be progressively de-aerated and to collapse, a condition referred to as that of a collapsing bed. In either case conditions are so controlled that the entire coating material in contact with the surface being coated is in a condition essentially more rarified than the powder in its loosest possible self-supporting form while the coating builds up.

The above-specified intermediate condition results in particular advantages as compared with the old methods of either coating

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in a fluidised bed or in a loosely settled powder. Thus (a) the disturbing effect of turbulent fluidised bed coating material on the quality of the coating being formed is eliminated; (b) bubbles and channels in the powder bed which are practically unavoidable in fluidised bed operations and which detract from the quality of the coating are avoided virtually completely; (c) on immersion of a heated article into the bed in the intermediate condition, which article forms an obstacle to the rising aerating gas, the properties and uniformity of the powder bed are either not disturbed at all or to a far lesser degree than in the case of a fluidised bed; (d) small cracks, hidden corners, and welding seams are easily coated by the method as opposed to a fluidised bed process, since in the fluidised bed process the higher velocity of the rising gas stream tends to pull powder particles away from such portions of the article to be coated; (e) the loss of heat of a preheated article when employing the particular state of aeration takes place at a fraction of the rate at which heat is lost under fluidised bed conditions. Under fluidised bed conditions a sheet iron 1 mm. thick immersed in a fluidised bed for six seconds has to be initially heated to a temperature more than 60 degrees higher than when coating with the process because of the higher rate of heat transfer in the fluidised process, and which elevated temperature is detrimental in the case of employing comparatively heat-sensitive plastic powders; (f) in spite of the fact that a powder bed employed under the conditions specified has all the flow properties required for the coating process, and offers virtually no resistance to objects being immersed therein, the powder under optimum coating conditions is often found to be 30 per cent less diluted with aerating gas than in the case of a fluidised bed and is obviously in a more concentrated form; (g) the process results in a considerable saving of aerating gas since the particular state of aeration requires only about half the gas required to maintain a fluidised bed.

All the above advantages are fully utilised in accordance with the present disclosure as well. Moreover, when coating elongate articles as specified above particular additional advantages are observed. Thus it will be found, if the degree of aeration is increased so as to form a fluidised bed, that bubbles will form along the underside of the immersed article being coated, thereby seriously affecting the quality of any coating that may form. The larger the diameter (transverse to the said longitudinal axis of the elongate article) happens to be the more serious this effect becomes. On the other hand, if a completely unaerated powder is used the said revolving motion will have the effect of scraping particulate material away from one side of the article and piling it up on the other side, said effect again becoming more serious the larger the diameter of the article. The employment of the said intermediate condition serves to avoid these defects. For the best results in terms of quality and uniformity of the coating the entire bed in as far as it is in contact with the article being coated is caused to be in an essentially uniform condition at any one time in respect of all properties which affect the coating formation, the bed in the said intermediate condition having a bed viscosity nearer to the bed viscosity of a fluidised bed than to the bed viscosity of the material in its loosest possible settled state.

In the said intermediate condition the bed is non-turbulent; accordingly the rotation of the article being coated produces a wiping effect of the coating material over the surface being coated. This effect enhances the quality of the coating considerably and cannot be duplicated in any other condition of the bed.

Of the two alternatives previously referred to the constantly maintained static aerate condition is usually found to be the more convenient to employ, for which reason the preferred process is carried out in such a manner that the bed in contact with the article is maintained in a static aerate condition, maintained essentially constant over a prolonged period, a static aerate being defined as an aerated condition maintained by gas flowing through the bed essentially more rarified than the most rarified condition in which the material can exist completely self-supportingly over a prolonged period, there being essentially no observable relative movement between the particles of the bed brought about by the gas flowing therethrough. Preferably the condition of the bed is maintained essentially constant during the entire period of contacting. The process is applied with particular advantage to the external coating of elongate articles having outlines essentially circular around the said axis of elongation, e.g. cylindrical rods, and is particularly applied to the external coating of pipes. Particular advantages are attained in cases where the diameter of the cylindrical articles is at least 3 inches. When coating pipes, the ends of such pipes are normally kept closed during the coating process in order to prevent the entrance of coating material inside the pipe being coated. However, it is possible to modify the process in such a manner that coating material fills the entire inside of the pipe for the simultaneous coating of the ouside and inside of the pipe.

Also in accordance with a further preferred feature of the invention the whole

length of each article to be coated is immersed simultaneously.

According to a further preferred feature of the invention, again particularly applicable where the diameter of the article is at least 3 inches, the article being coated is immersed only for part of its diameter along the entire length of the article, say to the extent of at the most two-thirds of its diameter preferably at the most one-half of its diameter, preferably not less than two inches in depth and subjected to at least two complete revolutions while thus partly immersed, preferably between two and ten revolutions, say 5 revolutions.

In this case, when coating a cylindrical surface, by far the greater part of the surface which at any one moment is in contact with the coating material is downwardly directed. As pointed out further above the advantages of the intermediate condition herein specified become particularly noticeable in such cases.

A preferred rate of revolving the article being coated is of the order of one foot per second arc velocity of the circumference. However, the arc velocity can be varied within wide limits, say between one inch per second and 6 feet per second, preferably between $2\frac{1}{2}$ inches per second and 6 feet per second, the exact choice depending on the diameter of the article being coated.

The process is particularly suitable for coating heated articles with fusible particulate materials, e.g. bitumen powder or thermoplastic resin powders or uncured or partly cured reaction curing resin powders or wax powders, said powders being fused at the particular temperature of the article at least to the extent necessary to adhere to the surface being coated. The article is preferably pre-heated to a temperature just sufficient to cause the adherence of the desired amount of coating material in the course of as little as a few seconds, for example, less than 20 seconds, preferably less than 10 seconds, say, about 5 seconds of total immersion time, and preferably the article is subjected to radiant heating immediately after the immersion period in order to completely fuse the adhering material into a coherent coating. Once again it is found that the said intermediate state of aeration produces particular advantages due to the fact that heat losses to the bed of coating material are much less than heat losses which would take place in a fluidised bed under otherwise identical conditions, the result being that lower preheating temperatures can be employed than would otherwise be possible.

It is usually found that post-fusion with radiant heat may be completed in a period between say 10 to 60 seconds, more particularly 10 to 30 seconds, e.g. 20 seconds.

In accordance with a further optional feature of the invention the body to be coated may be caused to move through the bed in a rolling movement, e.g. while supported on thin edges in order to cause a minimum of damage to the coating being formed, said damage being easily repairable afterwards. In order to further reduce the said damage, the said narrow edges may be toothed so that they will only produce point marks in the coating. Such point marks may, in favourable cases, even close up in the course of subsequent fusing out of the coating. A preferred method of repairing the slight damage caused by the said narrow supporting edges comprises rolling the damaged part of the coating over a smooth surface to which the coating material does not adhere, while the coating is still soft. In the case of coating by fusion it is usually found adequate for the said smooth surface to be chilled. However, where necessary the surface may be treated with a release agent. Alternatively, a pattern may be embossed onto the coating by rolling the coated article over a contoured surface.

Where coating is carried out by fusion the coating is preferably chilled after it has been fused out completely, preferably by contact with water. For this purpose the coated article may, for example, be allowed to roll over an inclined surface over which water or other cooling liquid is running, more particularly preferably a resilient foam surface, e.g. foam plastic or foam rubber surface. The cooling water may be recirculated. If desired or required, particularly in the case of large diameter articles, air current cooling may precede the water quenching operation.

While the coating by fusing heat-fusible powders is a particularly important application of the process, it is not the only possible application. Powders may be caused to adhere by other means, e.g. electrostatically or by rendering the surface to be coated tacky with an adhesive prior to contacting with the powder. The powder (the term "powder" being used in the widest sense) may then be fused after having been caused to adhere in the alternative manners just specified. However, fusion is not essential in all cases. When the surface has previously been coated with an adhesive substance the adhesive layer may be contacted with beds of fine glass beads, sand, adrasive minerals or any other suitable beds of particulate solid substances in terms of the process. It is also possible to apply an adhesive layer over a layer of particles thus caused to adhere, e.g. by spraying.

It is also of particular importance when carrying out the process to maintain the upper surface of the bed horizontal and at a substantially constant level. As has been explained above a powder in the said intermediate condition has an angle of repose,

however, a horizontal upper surface may be maintained by rocking the powder bed (which, as a side effect also helps to maintain an evenly aerated static aerate). An alternative and preferred method of producing a horizontal upper free surface is completely to fluidise the powder bed intermittently, more particularly between successive coating operations.

The powder bed should be replenised continuously or intermittently as powder is used up; if intermittently, then at frequent intervals, e.g. between successive coating operations. A constant powder level may be maintained by continuously or intermittently allowing powder to overflow over a weir or the like, e.g. from a fluidised bed of powder.

In order to bring the elongate article into contact with the bed the article may be lowered into the vessel containing the bed or alternatively the bed of coating material may itself be raised until it comes into contact with the article, either by raising the whole container in which the powder bed in the said intermediate condition of aeration is maintained or by displacing the aerated powder from a lower position to a higher position by a method such as that described in our application No. A 29479/61 or Pat. No. 912,464.

As a further important preferred feature of the invention applicable to the coating by fusing a fusible particulate coating material, the coating material is caused to adhere to the surface being coated during the period of contacting and to fuse incompletely only during the period of contacting, the incompletely fused adhering coating material being subjected to a compacting step immediately after the coating material has been caused to adhere, the adhering material then being fused completely after the compacting step and thereafter subjected to solidification. This sequence of steps has been found to be so effective that it will even eliminate to a considerable extent the blemishes which will result if, for any reason whatsoever, the bed conditions are not controlled properly within the intermediate range previously specified, for example, if by a momentary variation of the air pressure in a compressed air supply system of a factory, the properties of the powder bed should either approach those of a loosely settled powder bed or the bed should become fluidised.

Also in accordance with the invention an apparatus is provided suitable for carrying out the process, said apparatus comprising in combination an aerating vessel for producing a dense aerated bed of the coating material; a ramp section sloping towards the aerating vessel for carrying the articles towards the aerating vessel; means for guiding the articles and the bed vertically one towards the other; spaced apart means independent of the coating material for supporting the articles while in the bed against sinking to the bottom of the bed; means for engaging the elongate articles while immersed in the bed and for bringing about rotatary movement of the article around its axis of elongation; a ramp section sloping away from the aerating vessel for conveying the articles away from the aerating vessel after having been immersed in the bed. Other apparatus features and further details of the process will be described by way of example in the following with reference to the accompanying drawings: —

In the drawings Fig. 1 represents a diagrammatic side elevation, partly in section, of a pipe coating plant in accordance with the invention;

Fig. 2 illustrates in front elevation part of a pipe to be coated supported on a narrow edge of a supporting rail in a coating plant such as illustrated by Fig. 1;

Fig. 3 illustrates in side elevation the use of toothed supporting rails in a pipe coating plant such as that illustrated by Fig. 1;

Figs. 4, 5 and 6 illustrate diagrammatically in side elevation, partly in section, how pipes to be coated may be raised and lowered into a bed of particulate coating material;

Fig. 7 illustrates in plan view an arrangement for at least partly eliminating marks left by the supporting rails for pipes in a coating installation in accordance with the invention;

Fig. 8 illustrates one arrangement for moving pipes to be coated through sections of the pipe coating plant by rolling movement;

Figure 9 illustrates diagrammatically an arrangement for supporting and revolving pipes being coated while immersed in the coating material;

Fig. 10 illustrates an alternative arrangement for supporting pipes being coated during their passage through the coating apparatus such as that illustrated in Fig. 1;

Fig. 11 illustrates diagrammatically in side elevation, partly in section, an alternative detail to an apparatus such as that shown in Fig. 1;

Fig. 12 illustrates in front elevation, partly in section, an alternative arrangement for supporting a pipe being coated during its passage through a coating apparatus, e.g. incorporating the features shown in Fig. 11;

Figs. 13 to 15 represent in vertical section and partly in side elevation details of a further alternative embodiment of a plant for externally coating pipes, rods or similar elongate articles in three different stages of the coating operation;

Fig. 16 represents a partly sectionalised side elevation of an alternative plant to the one illustrated in Fig. 1, Fig. 17 representing

an elevation along line XVII—XVII, but on a smaller scale;

Figs. 18 and 19 illustrate diagrammatically in side elevation one manner of compacting a partly fused coating layer on the outside of a cylindrical body being coated prior to complete fusion; and

Figs. 20 and 21 illustrate an alternative embodiment in side elevation and plan view respectively.

Referring now to the drawings:

In Fig. 1 a system of support rails *1* is provided over which pipes *2* to be coated roll in the course of their passage through the coating apparatus. The pipes are thick-walled steel pipes having an external diameter of 4 inches and are to be coated externally with an 0.015 inch layer of polyvinylchloride. Polyvinylchloride powder (PVC) is contained in aerating vessel *3*. The PVC has a K-value of 50 and contains 20 parts per 100 of plasticiser. The aerating vessel, in principle, is of conventional design having a gas pervious bottom *4* underneath which there is a gas chamber *5* with an inlet for compressed air *6*.

The pipes *2* are first preheated in an oven *7* to a temperature of 220°C. Preheated pipes *2a* are allowed to roll out of the oven one by one. Pipe *2b* has in this manner already entered the aerating vessel *3* in which the coating powder is maintained in the condition of a static aerate as described further above.

(As an alternative the aerating vessel *3* is replaced by a two-compartment vessel in one compartment of which powder is continuously fully fluidised, fluidised powder being continuously conveyed to the top of the other compartment where the powder bed collapses and becomes partly de-aerated, the partly de-aerated powder being withdrawn continuously from the bottom of the collapsing bed and returned to the fluidising compartment. The coating operation then takes place in a continuously maintained collapsing bed.)

The pipe is immersed approximately between halfway and two-thirds and at least 2 inches deep in the static aerate. The pipe is passed through the powder bed in the course of 5 seconds and describes approximately 5 turns during its passage through the bed. When it leaves the bed (*2c*) it is maintained for 20 seconds between infra-red radiators *8* and *9* to allow the coating adhering to the pipe to fuse completely. Alternatively the radiators *8* and *9* may be omitted. However, in that case the pipe will have to be preheated to a higher temperature, namely, approximately 250°C. When the pipes leave the infra-red radiation zone they are chilled to cause solidification of the coating. In the case of large diameter pipes it is preferred first to subject the pipes to air cooling, e.g. with blasts of air ejected through nozzles *10* and *11*. The partly cooled pipes *2d* are then subjected to water chilling by allowing them to roll over a sloping foam rubber surface *12* over which water *13* is constantly running from a container *14*. The water running over the foam rubber surface is collected in a container *15* and recycled to container *14* by means of a pump *16*. When necessary the coated pipes *2e* are now further processed to repair any marks left by the rails *1*. This is preferably done with a reaction curing trowelling substance, e.g. containing an epoxy resin.

Referring now also to Fig. 2, the guide and supporting rails *1* preferably have a narrow supporting edge *17* in order to reduce the extent of the damaged part *18* of the coating to a minimum.

Referring now to Fig. 3 the damage may be further reduced by using toothed rails *1a* which merely leave point marks which, in favourable cases, may close up by themselves as a result of the post-fusing treatment in infra-red radiation zone *8, 9*.

Referring now to Fig. 4 part of the rail *1* above the aerating vessel *3* is replaced by cables or chains *1b* having a fixed support *19* at one end and connected to a drum or pulley *20* at the other end. To lower the pipe *2b* into the bed of coating material a length of cable or chain *1b* is allowed to run off the drum or pulley *20*. Accordingly the pipe *2b* is lowered (broken lines) and at the same time describes a rolling movement while rolling down the slope provided by the sagging chains or cables. The procedure is reversed to raise the pipe.

Referring to Fig. 5 the rails *1* in the portion above the aerating vessel *3* are replaced by two rail sections *1c* and *1d* hinged to one another at their one end *21* while their other ends are hinged at *22* and *23* respectively to horizontally movable section *1e* and *1f*. To lower the pipe *2b* into the bed of coating powder hinge points *21* are lowered (e.g. by lowering a support diagrammatically indicated by *24*) as a result of which sections *1e* and *1f* move closer together. To raise the pipe the procedure is reversed.

Referring to Fig. 6 rail *1* comprises a downward kink *1g* inside aerating vessel *3*. In one operating position of the apparatus the kink *1g* is bridged by a bridging device *25* which is adapted to be raised and lowered. When a pipe *2b* moves over the rails *1* in the direction of the arrow the bridging device *25* is gradually lowered to allow the pipe to roll down into the kink *1g*. If desired or required the pipe, while in the lowered position, may be grabbed by additional means not shown in order to be rotated in addition to the rotary movement resulting from rolling down into the kink. The bridging device *25* is then raised once again to raise the pipe out

of the aerating vessel and to allow it to proceed further in the direction of the arrow. The bridging device *25* may be adapted to be raised and lowered and simultaneously to be tilted slightly with the result that the pipe is not only raised and lowered but also guided horizontally to move along the contours of the kink *1g* in the direction of the arrow.

Referring now to Fig. 7 the blemishes *18* remaining on pipes *2c* after the passage through the infra-red radiation zone *8, 9* and resulting from rails *1* may be diminished or repaired by extending the narrow-edged rails *1* beyond the infra-red zone by wide and flat rails *1h*. Cooling water may be circulated through these rails *1h* in order to keep their surface chilled. As the pipe $2c^1$ rolls over the surface of rails *1h* the damaged portions *18* are at least partly eliminated.

Referring to Fig. 8 the pipes *2* may be moved along rails *1* in any part of the apparatus including the bed of aerated coating powder by means of a transporting device comprising an endless conveyor chain or the like *26* with transporting arms *27* projecting therefrom. The transporting arms *27* may simply engage the outside of the pipes *2* and push them along the rail *1*. Alternatively the arms *27* may hook inside the pipes with hooks or rollers.

Referring to Fig. 9, large diameter pipes are preferably turned through a larger number of revolutions while immersed in the powder bed than would be possible by mere rolling movement of the pipe from one side of the bed to the other. For example, while in the aerated bed of coating powder the pipe may be rotated while its advance movement is interrupted. As shown in Fig. 9 the ends of the pipe are to be left uncoated and are engaged by cups *28* and *29*, one of which has an axle *30* supported by any suitable bearing, whereas the other cup is connected to a driven shaft *31*, driven by any suitable means not shown. In the case of very long pipes it may still be necessary to support the pipes at intermediate points, e.g. at *32* and *33*. The supports may be in sliding relationship with the pipe or they may take the form of narrow supporting wheels.

Referring to Fig. 11, the pipe, while entering, being in, and leaving the aerating vessel, may, instead of rolling over rails *1* be suspended from a suspending mechanism *34* which itself moves along a supporting rail *35*. Furthermore the pipe need not be raised and lowered itself but as an alternative the aerating vessel *3* may be raised and lowered to bring about contacting of the powder bed with the pipe, e.g. by means of a hydraulic raising and lowering mechanism *36*.

Referring to Fig. 12 the suspending mechanism indicated in Fig. 11 by *34* may for example comprise cones *37* which engage the inside of the pipe, said cones being mounted on axles which are rotatable in sleeves *38*, one cone idling and the other being driven, e.g. by a gear drive *39* or a chain drive. The sleeves *38* are connected to suspending arms *40* hinged at *41* to a carrying arm *42* connected to a carriage *43* which runs on rails *44*. The length of the beam *42* may be adjusted for the coating of pipes of different lengths.

Referring to Fig. 10 the end of pipes *2* are inserted in cups *45* having a wheel-like running surface *46* by means of which the pipes are rolled over any suitable supporting surface, e.g. the surface of a pair of rails *47*.

Referring now to Figs. *13* to *15*, the apparatus shown is particularly suitable for coating elongate cylindrical objects, e.g. rods or pipes, and the apparatus will be described with particular reference to pipes such as steel or other metal pipes.

The apparatus comprises a ramp or pipe feeding rack composed of sloping rails *50* spaced apart at say 10 ft. intervals for the coating of long pipes. These rails *50* slope into an aerating vessel *51* which is adapted to be raised and lowered and which is shown in the raised position in Fig. 13. Each rail *50* terminates in a notched, hinged stop member *52*, and Fig. 13 illustrates a pipe *53* engaged by the stop member. The pipe is partly immersed in a static aerate bed which is constantly maintained inside the aerating vessel *51*. While being thus partly immersed the pipe is rotated by means not shown, e.g. a mechanism similar to the one described with reference to Fig. 12.

The aerating vessel itself comprises a gas pervious bed support *54* of a type known per se underneath which an air box *55* is provided which is maintained under pressure by means of air blower *56*. Depending on the properties of the coating material particles it is often found advisable to agitate the lowermost part of the bed, i.e. the portion immediately above the bed support which is well removed from the part of the bed in contact with the article being coated. To this end a set of stirrers *57a* is provided having stirrer blades *57* the stirrer blades being evenly distributed over the entire surface of the bottom of the bed. The stirrers may be interconnected by a chain motor drive which is not shown in the drawing. The stirrers maintain a gentle agitation near the bottom of the bed. This agitation does not in itself produce any material movement near the top of the bed, but it does assist in maintaining the top part of the bed in a more suitable condition for coating process.

As a further feature the apparatus comprises an infra-red radiator *58* connected to the aerating vessel in a position above the surface of the bed. In the operating position

of the aerating vessel as shown in Fig. 13 the radiator is well above the pipe *53*. It radiates heat across the aerating vessel and in the general direction of the rails *50* but does not radiate directly onto the pipe *53*.

The aerating vessel *51* may be raised and lowered by means of pneumatic or hydraulic raising and lowering devices of a type known per se, which are not shown in the drawing. A quenching bath *59* is provided immediately next to the aerating vessel on the side opposite to the rails *50* and will be discussed in more detail further below.

Referring now particularly to Fig. 14, the pipe *53*, after having been contacted with the bed in vessel *51* for a few seconds, must be removed from the bed and subjected to a brief post-fusion treatment. For this purpose the vessel *51* is lowered partly to the position as shown in Fig. 14. In this manner radiator *58* is brought opposite pipe *53*, which is still maintained rotating while now being subjected to infrared radiation. The length of the post-fusion treatment depends entirely on the pre-heating temperature and heat capacity of the pipe, the fusion temperature of the coating material and the thickness of the coating. It can easily be determined by simple experiment for each particular case.

Referring now particularly to Fig. 15, the post-heating treatment is terminated by further lowering the aerating vessel as shown in the drawing. In addition the stop member *52* is tilted to release pipe *53*, which now rolls forward and drops into quenching bath *59*. The sloping bottom of quenching bath *59* is padded with foam rubber or foam plastic, e.g. foam PVC *60*. The cooling water *61* can, if necessary, be cooled by external cooling means not shown. Also, when the aerating vessel *51* is in its lowermost position a powder topping up device not shown in the preceding drawings comes into operation. It comprises a hopper *62*, a star feeder *63* which meters out a measured quantity of powder and a shute *64* hinged at *65* which is tilted into position to allow the measured amount of powder to flow into the aerating vessel. Subsequent to the operations illustrated by Fig. 15, the aerating vessel *51* is raised again to the position shown in Fig. 13. The stop member *52* is tilted upwards and a new pre-heated pipe rolls down the rails *50* into the position shown in Fig. 13.

Referring now to Figs. 16 and 17 of the drawings the complete installation comprises a preheating oven of conventional design which is not shown. A chain conveyor, one end sprocket of which is indicated by *70* conveys pipes through the oven and out of the oven onto a ramp *71*, in this example composed of 7 parallel rails *72* spaced approximately 7 ft. apart and having sharp upper edges. The pipes to be coated are released one by one by the chain conveyor as they emerge from the oven and roll down the ramp towards the aerating vessel *73* while the latter is in a half-lowered position. Each pipe then comes to rest on portion *74* of the ramp against stop member *75*, which is integral with the up-and-downwardly movable ramp section *76*, linked mechanically to the aerating vessel by means of a push-rod or equivalent *77*. The ends of the pipes are then engaged by a rotating mechanism. In one embodiment, as shown in Fig. 17, the rotating mechanism comprises a driving end *78* in a fixed position, a pipe engaging cup being represented by *79*, kept in rotation by a mechanism incorporated in the driving end, whereas a co-acting opposing tail end *80* adapted to engage the opposite end of the pipe with an idler cup *81* is slidingly mounted on a shaft *82*. The sliding movement may be actuated by a pneumatic or hydraulic arrangement not shown. When the said rotating mechanism has been brought into engagement with the pipe indicated by dotted line *83* in Fig. 16, the aerating vessel *73* in which a static aerate is maintained as explained before, is raised to its fully raised position as shown in Fig. 16 by means of a set of pneumatic or hydraulic lifting devices *84*, thereby partly immersing the pipe, which is simultaneously kept in rotation. After an immersion period of a few seconds the aerating vessel is lowered completely. The means *80* are actuated to release the pipe and simultaneously with the movement of the aerating vessel, ramp section *76* similarly moves downwards completely until it is level with portion *74* of the ramp, which causes the pipe to roll down along the incline of section *76* to position *85* in which the pipe is supported on ramp section *86* and prevented from moving further by stop member *87* which is now in a raised position *87a*. In position *85* the pipe is subjected to post-fusion by infra-red radiation supplied by infra-red heaters, of which one is indicated at *88*. When the aerating vessel *73* is again partly raised to prepare the apparatus for the reception of the next pipe to be coated, this movement simultaneously brings about the lowering of stop *87* to the position indicated by *87*, whereby the pipe is released and allowed to roll further down the incline of the ramp and into quenching vessel *89*, which is filled with water and has a sloping bottom *90* padded with PVC foam. Water from the cooling vessel may be pumped through outlet *91* to cooling devices and recycled to the cooling vessel. After quenching the pipes are removed from the apparatus.

In the just described method and apparatus the aerating vessel may contain a large variety of heat fusible powers, e.g. thermoplastic powders such as polyethylene, polyvinylchloride, chlorinated polyethers,

fluorocarbon resins, nylons, heat-curable resin powders such as powders of partly cured epoxy resins, wax powders, powders of bituminous substances, e.g. coal tar pitch, petroleum bitumen, including airblown bitumen and the like. If desired or required the aerating vessel may be preceded by a bath of primer substance, e.g. containing the primer known in the trade as "PLASTILOK" (manufactured by the B.F. Goodrich Company.)

It is also possible to provide two aerating vessels in succession in order to produce multilayer coatings. One of these aerating vessels may be charged with an unfusible powder, e.g. glass beads, sand or the like, of which a layer is caused to adhere merely by the tackiness of the layer produced in the preceding aerating vessel. As a further alternative the pipe or the like may first pass through a bath of adhesive substance and while the adhesive is still tacky be immersed in an aerated bed of such unfusible material.

When coating the elongate articles to which the present application relates with heat fusible, e.g. thermoplastic materials, it was furthermore found of particular advantage to carry out the coating process by immersing the pre-heated article in the thermoplastic material and immediately thereafter, that is, before the layer of particles adhering to the article had fused completely, subjecting the partly fused layer to a pre-compression step, whereafter the layer was fused completely. It was found that by so doing so the heat history of the coating could be reduced considerably. The coating was found to fuse with much greater ease and much more rapidly. Moreover the procedure enhances the evenness of the coating considerably. The precompression step can even be utilised to emboss a pattern onto the coating, which pattern can be caused to persit even after complete fusion of the coating. The principle can be applied with particular ease to elongate articles of cylindrical shape. For example, pipes or similar cylindrical articles may, immediately after their removal from the aerated coating powder bed, be caused to roll over a compacting surface. For example, in Fig. 16, the ramp section *76* may provide a smooth surface over which the pipes or similar cylindrical articles may roll. Such smooth surface is preferably soft and resilient. An alternative is illustrated by Figs. 18 and 19.

Referring to Fig. 18, an aerating vessel *100* contains a static aerate of thermoplastic powder, the upper surface of which is indicated by *101*. A pipe *102* is suspended partly immersed in the bed and kept revolving in the direction indicated by the arrow. A springloaded resilient roller *103* (cooled if necessary) compacts the layer of particles adhering to the pipe immediately after the pipe surface leaves the bed. In Fig. 19 the pipe is eventually lifted out of the bed. However, the roller *103* still remains in contact with the pipe surface. It is even possible to use the roller *103* to cause the revolving movement of the pipe. However, this need not necessarily be so.

Referring now to Fig. 20, the cylindrical object, immediately after leaving the bed of aerated material is dropped onto a pair of sets of compacting rollers *105*. The rollers *105* are motor driven, and even after one full revolution of the article *104* the layer of coating material adhering to the article is pre-compressed. Fig. 21 illustrates the arrangement in plan view. When very long articles are coated it may sometimes be found advisable to use sets of several short rollers rather than 2 long rollers, in order to ensure more even compacting of all parts of the surface of article *104*.

"Essentially dry solid particles" in this context is intended to mean particles which are essentially dry to touch and free of moisture films surrounding the particles so pronounced as, or tackiness sufficient to cause lump formation to become a predominating feature. The definition is not intended to exclude the presence of liquids, e.g. plasticisers or like modifying agents dissolved or dispersed in the particles themselves.

WHAT WE CLAIM IS:—

1. A process of externally coating elongate articles having an essentially straight axis of elongation by means of a particulate coating material composed of essentially dry solid particles, which comprises in combination immersing the elongate article in a bed of the said particulate coating material; bringing all parts of the bed in contact with the article into a condition of aeration intermediate between that known as a fluidised bed on the one hand and the condition of the particulate material in its loosest possible self-supporting condition on the other hand; causing particulate material of the bed to adhere to the surface of the article, at least half of the material being caused to adhere while the bed is in the above specified intermediate condition; supporting the article being coated during the entire period of contact with the bed against sinking to the bottom of the bed by means independent of the coating material; maintaining the axis of elongation of the article in an essentially horizontal position during the period in which the coating material is caused to adhere; revolving the article completely around its axis of elongation while in contact with the bed in the specified condition and while the coating material is being caused to adhere; and transforming the coating material adhering to the article

into a coherent layer surrounding the article.

2. A process as claimed in claim 1 in which the bed in contact with the article is maintained in a static aerate condition, maintained essentially constant over a prolonged period, a static aerate being defined as an aerated condition maintained by gas flowing through the bed essentially more rarified than the most rarified condition in which the material can exist completely self-supporting over a prolonged period, there being essentially no observable relative movement between the particles of the bed brought about by the gas flowing therethrough.

3. A process as claimed in claim 2 in which the condition of the bed is maintained essentially constant during the entire period of contacting.

4. A process as claimed in any one of claims 1 to 3 in which the outlines of the article are essentially circular around the said axis of elongation.

5. A process as claimed in claim 4 applied to the external coating of pipes.

6. A process as claimed in any one of claims 1 to 5 in which the article being coated is immersed only partly along the entire length of the article and is subjected to at least two complete revolutions while thus immersed.

7. A process as claimed in claim 6 in which the article is immersed to the extent of at the most two-thirds of its diameter and at least two inches in depth.

8. A process as claimed in any one of claims 1 to 7 which comprises moving the article being coated through the bed in a rolling movement.

9. A process as claimed in claims 4 or 5 or 4 and any one of claims 6 to 8 in which the article being coated, during at least part of the coating process, is supported on narrow edges.

10. A process as claimed in claim 9 in which the article being coated, during at least part of the coating process, is supported on narrow serrated edges.

11. A process as claimed in either of claims 9 or 10 in which, after having been supported on the said narrow edges the article is rolled forward while supported on broad supporting surfaces, said supporting surfaces contacting and overlapping all those parts which had previously been in contact with the narrow edges.

12. A process as claimed in any one of claims 1 to 11 carried out with a fusible particulate coating material, and which comprises fusing the particulate coating material adhering to the article into a coherent layer surrounding the article and cooling the article to cause solidification of the fused layer by immersing the article in a cooling liquid while the article is supported on a soft resilient supporting surface.

13. A process as claimed in any one of claims 1 to 12 in which the entire bed in as far as it is in contact with the article being coated is caused to be in an essentially uniform condition at any one time in respect of all properties which affect the coating formation, the bed in the said intermediate condition having a bed viscosity nearer to the bed viscosity of a fluidised bed than to the viscosity of the material in its loosest possible settled state.

14. A process as claimed in any one of claims 1 to 13 in which the particulate coating material is fusible; the coating material caused to adhere to the surface being coated during the period of contacting is caused to fuse incompletely only during the period of contacting; the incompletely fused adhering coating material being subjected to a compacting step immediately after the coating material has been caused to adhere and the adhering material then being fused completely after the compacting step and thereafter subjected to solidification.

15. A process substantially as hereinbefore described.

16. An apparatus for externally coating elongate articles having an essentially straight axis of elongation by means of a particulate coating material composed of essentially dry solid particles which comprises in combination an aerating vessel for producing a dense aerated bed of the coating material; a ramp section sloping towards the aerating vessel for carrying the articles towards the aerating vessel; means for guiding the articles and the bed vertically one towards the other; spaced apart means independent of the coating material for supporting the articles while in the bed against sinking to the bottom of the bed; means for engaging the elongate articles while immersed in the bed and for bringing about rotatory movement of the article around its axis of elongation; a ramp section sloping away from the aerating vessel for conveying the articles away from the aerating vessel after having been immersed in the bed.

17. An apparatus as claimed in claim 16 comprising a single downwardly sloping ramp passing over the aerating vessel and comprising parts which are movable up and down relative to the remainder of the ramp.

18. An apparatus as claimed in claim 16 or 17 in which sections of the ramp are movable relative to one another so as to act as stops for articles moving down the slope of the ramp.

19. An apparatus as claimed in any one of claims 16 to 18 in which the ramp comprises a plurality of spaced apart narrow-edged rails followed in alignment by broad supporting rails.

20. An apparatus as claimed in claim 19

in which the upwardly directed side of the narrow rails is sharply indented.

21. An apparatus as claimed in any one of claims 16 to 20 in which the ramp section sloping away from the aerating vessel for conveying the articles away from the aerating vessel after having been immersed in the bed comprises a portion padded with soft resilient material, said portion being adapted to be submerged under cooling liquid.

22. An apparatus as claimed in any one of claims 16 to 21 in which the means for supporting the article while in the bed and the aerating vessel are movable vertically relative to one another, the apparatus furthermore comprising an infra-red radiator movable relative to the said means for supporting the article in conjunction with the aerating vessel, the radiator being at all times above the surface of the aerating bed and being adapted to be brought into a position to radiate heat onto the article being coated when the bed is in a lowered position with regard to the means for supporting.

23. An apparatus as claimed in any one of claims 16 to 22 in which the aerating vessel comprises rotatable stirrer blades distributed over the bottom of the aerating vessel and provided immediately above the bottom of the aerating vessel.

24. A coating apparatus comprising the features substantially as hereinbefore described.

25. A coating apparatus substantially as described with reference to any one or more of Figs. 1 to 12.

26. A coating apparatus substantially as described with reference to any one or more of Figs. 13 to 21.

27. Articles coated by a process or with an apparatus as claimed in any one of claims 1 to 12, 16 to 21 or 25.

28. Articles coated by a process or with an apparatus as claimed in any one of claims 13 to 15, 22 to 24 or 26.

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Fig. 1

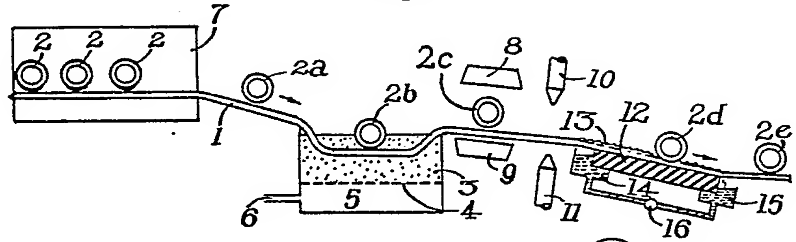


Fig. 2

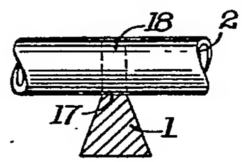


Fig. 3

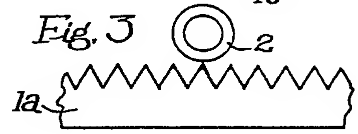


Fig. 5

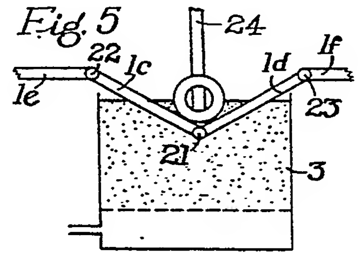


Fig. 4

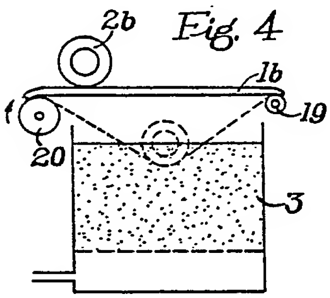


Fig. 7

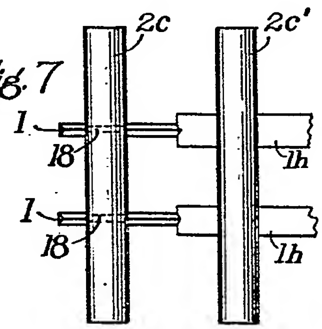
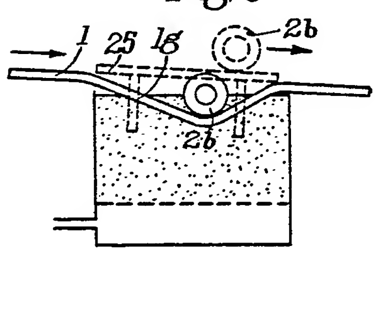


Fig. 6



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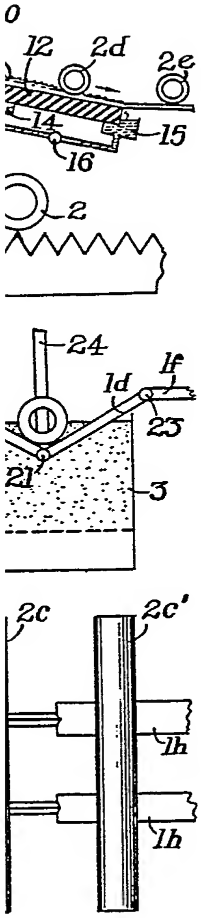

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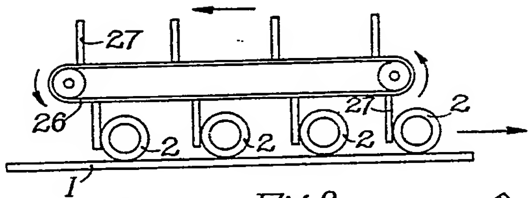

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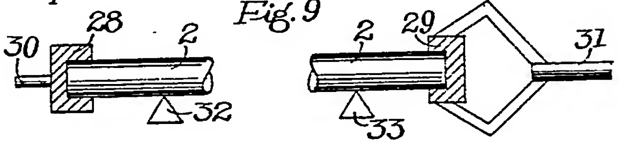

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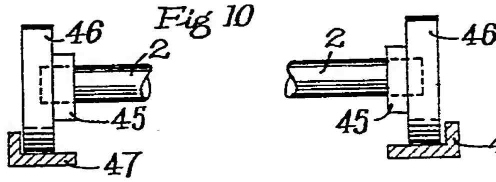

Fig. 12

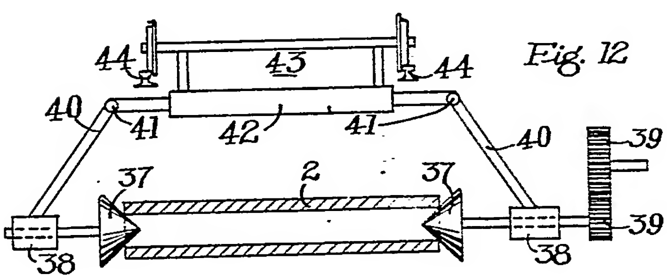

Fig. 11

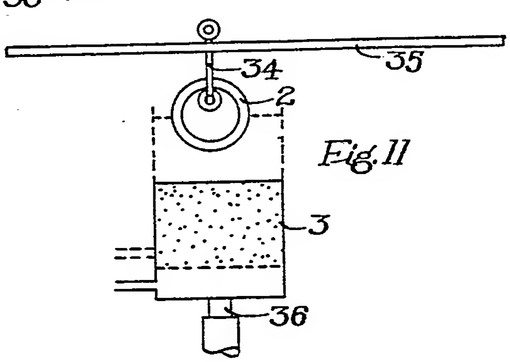

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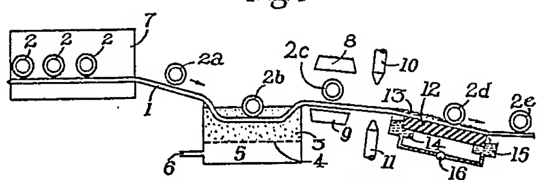
Fig. 1



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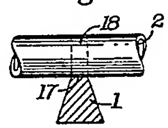
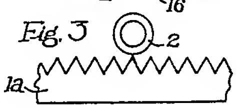


Fig. 3



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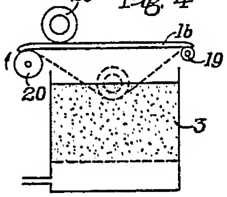

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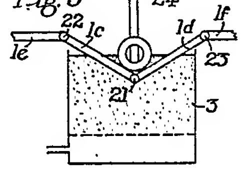
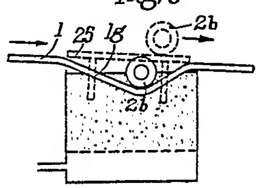


Fig. 6



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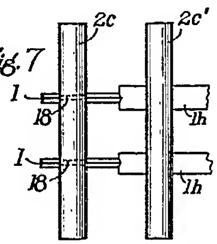

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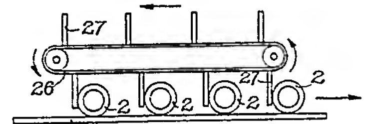

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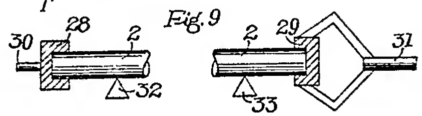

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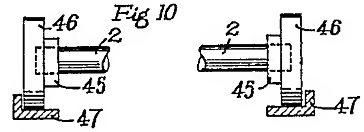

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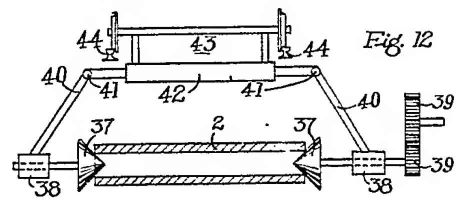

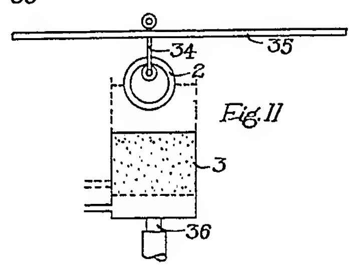

Fig. 11

Fig. 13

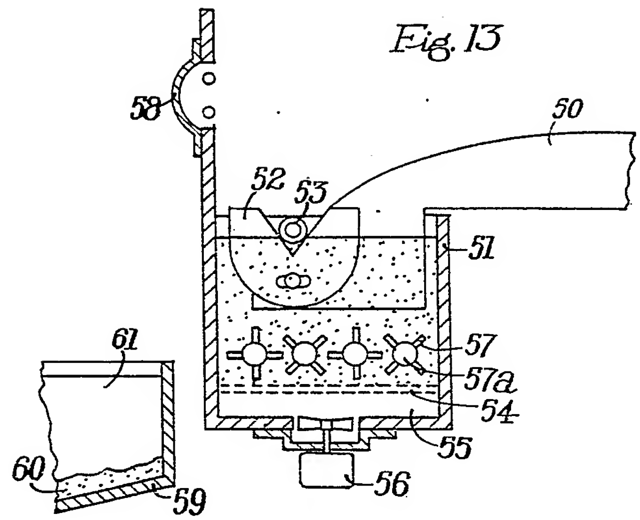

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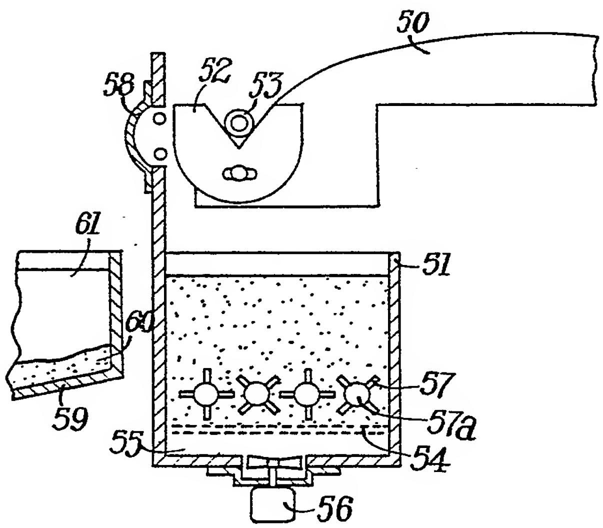
Fig 14



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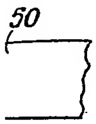

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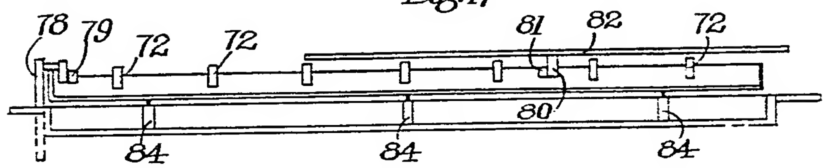

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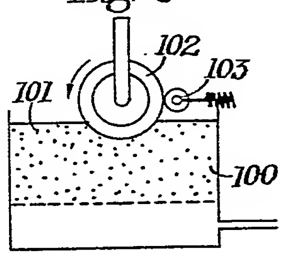

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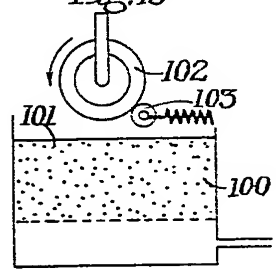

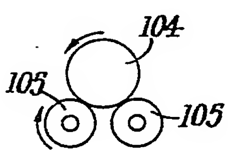

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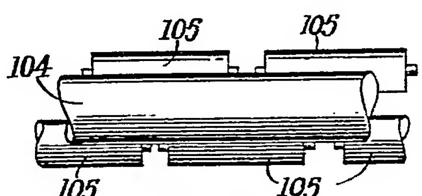

Fig. 21

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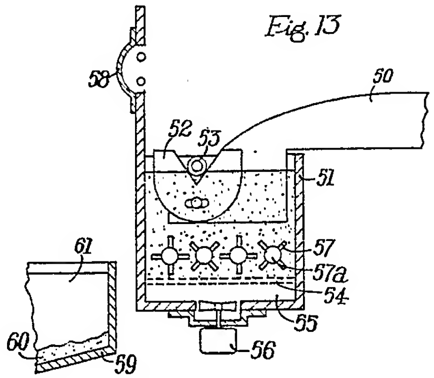
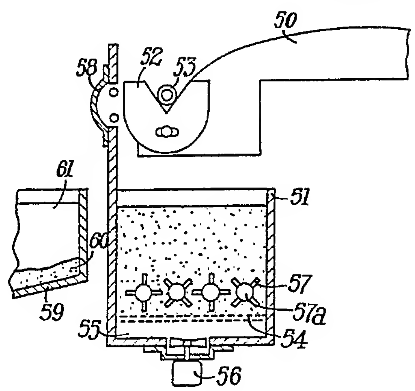


Fig. 13



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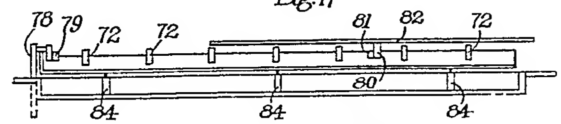


Fig. 17

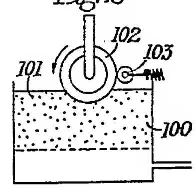


Fig. 18

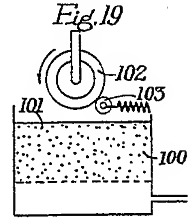


Fig. 19

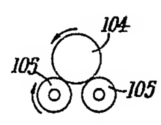


Fig. 20

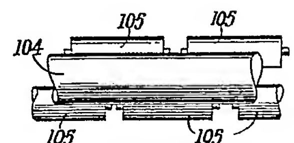
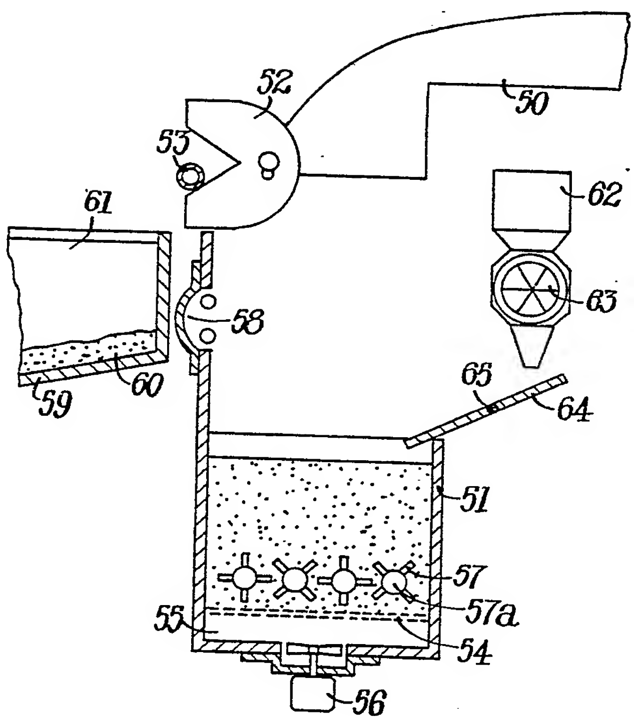


Fig. 21

Fig. 15



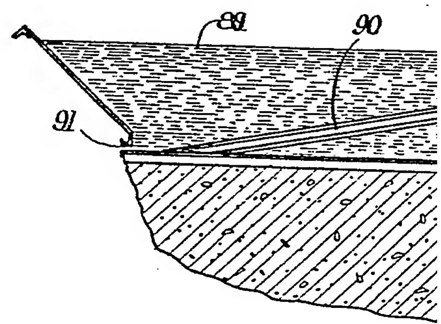


Fig.16

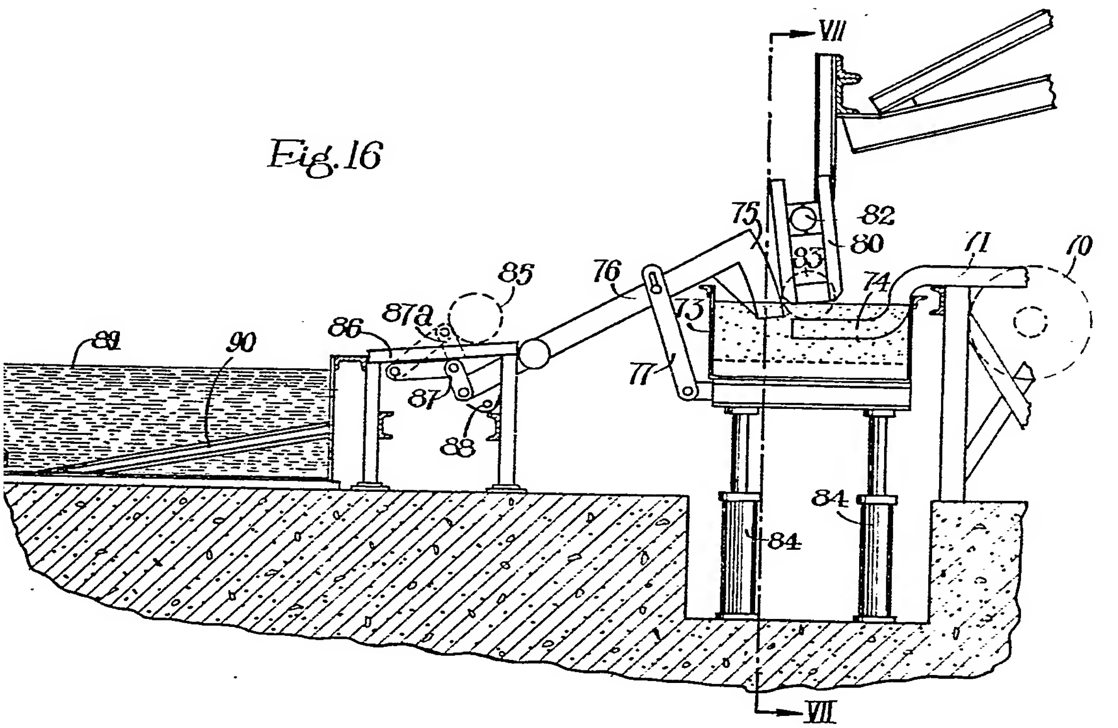


Fig.15

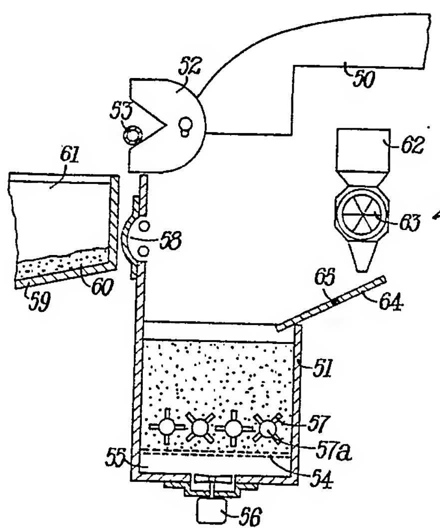

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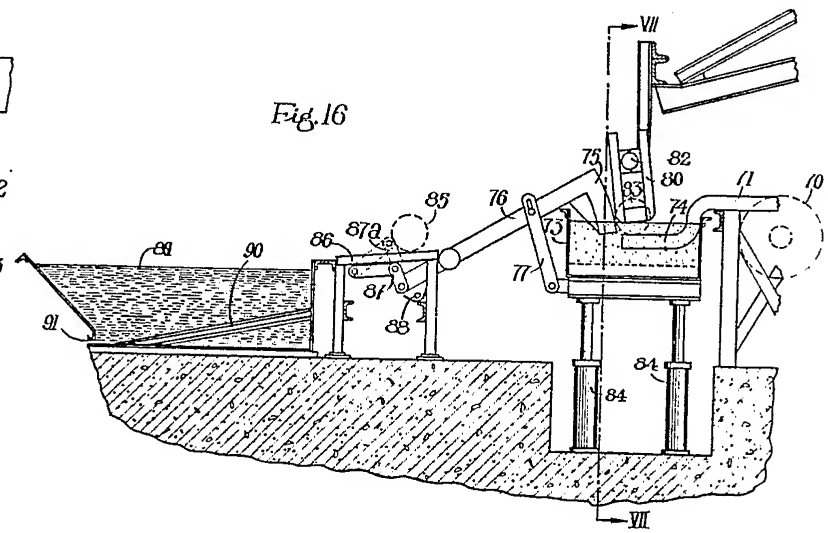
Fig.16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